

CLAIMS

What is claimed:

1. A method of forming a copper layer on a substrate, comprising:
 - 5 forming a copper oxide layer from a non-fluorine containing copper precursor on the substrate; and
 - reducing the copper oxide layer to form a copper layer on the substrate.
2. The method of Claim 1 wherein the steps of forming a copper oxide layer and reducing the copper oxide layer are carried out at substantially the same temperature.
3. The method of Claim 2 wherein the steps of forming a copper oxide layer and 10 reducing the copper oxide layer are carried out at a temperature in the range of about 100 to 300°C.
4. The method of Claim 1 wherein the step of forming a copper oxide layer comprises depositing the copper oxide layer by atomic layer deposition comprising alternatively reacting the surface of the substrate with a non-fluorine containing copper precursor and an 15 oxygen containing gas, at a temperature below about 200°C.
5. The method of Claim 4 wherein the non-fluorine containing copper precursor is a copper alkoxide, copper β -diketonate or copper dialkylamide.
6. The method of Claim 5 wherein said copper alkoxide comprises $[Cu(t\text{-}BuO)]_4$, said copper β -diketonate comprises $Cu(\text{tetramethylheptadionate})_2$, and said copper dialkylamide 20 has the formula of $[Cu(NR_2)]_4$ where R represents alkyl.
7. The method of Claim 4 wherein said oxygen containing gas is ozone, oxygen, water or any mixture thereof.
8. The method of Claim 1 wherein the step of reducing the copper oxide layer comprises reducing the copper oxide layer by contacting with a hydrogen containing gas at a 25 temperature below about 200°C.

9. A method of forming a copper film on a substrate, comprising:
introducing a non-fluorine containing copper precursor gas about a substrate provided
in a chamber;
removing excess copper precursor gas from the chamber;
- 5 introducing an oxygen containing gas into the chamber to form a layer of copper
oxide on the substrate;
removing excess ozone from the chamber; and
introducing a hydrogen containing gas into the chamber to reduce the copper oxide
layer to form a copper layer.
10. 10. The method of Claim 9 wherein the steps of forming the copper oxide layer and
reducing the copper oxide layer are carried out at a temperature of below about 200°C.
11. 11. The method of Claim 9 wherein the steps of forming the copper oxide layer and
reducing the copper oxide layer are carried out at a pressure in the range of about 100 mTorr
to 10 Torr.
15. 12. The method of Claim 9 wherein the non-fluorine containing copper precursor is a
copper alkoxide, copper β -diketonate or copper dialkylamide.
13. 13. The method of Claim 12 wherein the non-fluorine containing copper precursor is
selected from the group consisting of $[\text{Cu}(\text{t-BuO})]_4$, $\text{Cu}(\text{tetramethylheptadionate})_2$, and
copper dialkylamide.
20. 14. The method of Claim 9 wherein the oxygen containing gas is ozone, oxygen, water,
or any mixture thereof.
15. 15. The method of Claim 14 wherein the oxygen containing gas is ozone.
16. 16. The method of Claim 9 wherein the copper precursor is introduced at a flow rate in
the range of about 1 to 1000 sccm.
25. 17. The method of Claim 9 wherein the copper precursor is introduced in pulse at a pulse
time of about 0.01 to 10 seconds.

18. The method of Claim 9 wherein the oxygen containing gas is introduced at a flow rate in the range of about 100 to 2000 sccm.